

## **REMARKS**

Applicants respectfully request reconsideration of the present application in view of the foregoing amendments and in view of the reasons that follow. A detailed listing of all claims that are, or were, in the application, irrespective of whether the claim(s) remain under examination in the application, is presented, with an appropriate defined status identifier.

No claims are cancelled, amended or added. Claims 1-13 and 15-17 are now pending in this application.

### **I. The Obviousness Rejections Should Be Withdrawn**

Claims 1-7, 9-13 and 15-17 have been rejected under section 103(a) over US Patent 5,964,965 (“US ‘965”). Claims 1-13, 9-13 and 15-17 have been rejected under section 103(a) over WO 97/26214 (“WO ‘214”). These rejections are respectfully traversed.

#### **A. Prior Art Does Not Teach Grinding a Metal Hydride**

Claim 1 of the present application recites subjecting magnesium or a magnesium-based compound known to absorb hydrogen, to a hydrogenation in order to obtain a hydride in the form of a powder, mixing the so-obtained hydride in a powder form with the other element(s) or compound(s) or with a hydride of said other element(s) or compound(s) to obtain a mixture, and subjecting the so-obtained mixture (i.e., the mixture containing the hydride) to an intensive mechanical grinding in order to obtain a composite of nanocrystalline structure in the form of a hydride.

In other words, claim 1 of the present application recites that the starting material is a metal which is subject to hydrogenation which results in a metal hydride. The metal hydride is then ground into the claimed nanocrystalline metal hydride structure.

In contrast, US ‘965 and WO ‘214 disclose that the starting material is a metal. This metal is then ground into a nanocrystalline powder. Thus, US ‘965 and WO ‘214 do not teach or suggest grinding a metal hydride into a nanocrystalline structure or powder, as

recited in claim 1 of the present application. There is no teaching or motivation in US '965 and WO '214 to subject a metal hydride to grinding to form the metal hydride nanocrystalline structure. Therefore, it is submitted that a *prima facie* case of obviousness has not been established and that the claims of the present application are not obvious over US '965 or WO '214.

#### **B. Unexpected Results**

Even if a *prima facie* case of obviousness is established, then the *prima facie* case is rebutted with evidence of unexpected results.

The present specification notes that if magnesium hydrides or magnesium based alloy hydrides are used as the starting material in combination with another second element or compound known to absorb hydrogen instead of using magnesium or magnesium based alloys in combination with the same second element or compound, then one may obtain a composite of nanocrystalline structure having a superior performance compared to what could be foreseen before.

In the two prior art references used in the rejection, it is disclosed that nanocrystalline powders capable of absorbing hydrogen at high temperatures can be prepared. However, the starting material is a metal or a metal alloy, such as a magnesium or a magnesium based alloy, but not a metal hydride. These references do not suggest to use a magnesium hydride or a magnesium based alloy hydride as a starting material.

Figures 1 to 5 of the present application illustrate the performance of nanocrystalline Mg and nanocrystalline Mg-V composites made by ball milling using the prior art method where the starting material is a metal rather than a metal hydride, as disclosed for example in US '965 and WO '214. The hydrogen absorption/desorption requires a high temperature and the kinetics are still relatively slow.

In contrast, the performance of MgH<sub>2</sub> – V metal hydride nanocomposite made using the magnesium hydride starting material according to of an embodiment of the present invention is illustrated in Figures 10 to 15 of the present application and described on pages 7-10 and 13-14 of the specification, for example. It can be seen from these figures that by using the magnesium hydride starting material, the hydrogen absorption/desorption kinetics are at least one order of magnitude faster than in the prior art method illustrated in Figures 1 to 5. This is clearly an unexpected breakthrough on solving the slow kinetic problem.

### **C. Applicants Disagree With the Reasoning in Office Action**

The Office Action states that “one of ordinary skill in the art would clearly be motivated to make those claimed compounds and steps in searching for new products in the expectation that compounds similar in structure will have similar property”. Applicants respectfully disagree for the following reasons.

(a) Hydrogen absorption/desorption is a very complex process involving hydrogen dissociation and chemisorption on the surface, surface penetration by hydrogen atoms, hydrogen diffusion in the metal and hydride phase, nucleation of the hydride or metal phase and motion of the interface between the metal and hydride. Nanocrystalline structure is only one of many factors that might influence the hydrogen diffusion. Ball milling of Mg with catalyst can generate a nanostructure. However, not all catalyzed nanostructured Mg provides fast hydrogen absorption kinetics.

(b) The performance of ball milled Mg-V nanocomposite made by using the prior art method and the exemplary MgH<sub>2</sub>-V nanocomposite made by a method of an embodiment of present invention are significantly different, indicating that their structures and properties are not similar, although they both have nanometer grain size.

(c) It is believed that the distribution of catalysts, the size and shape of nanocatalyst particles, the interface of the catalysts with metal hydrides and the type of catalyst being used and the interaction of catalyst with the metal hydride matrix effect hydrogen

absorption/desorption kinetics of magnesium hydride and other complex hydrides. Materials merely having a similar nanostructure size and fine distribution of catalyst would not necessarily have similar kinetics or properties. For example, even among metal hydrides, MgH<sub>2</sub>-V and MgH<sub>2</sub>-Nb, as shown in Figs. 10 to 18, provide improved results compared to the MgH<sub>2</sub>-Pd nanocomposite, as shown in Fig. 20, although Pd is the best known catalyst for hydrogen absorption/desorption. Pd is also used in the US '965 patent cited in the Office Action. Thus, it is clear that a person of ordinary skill in the art would not be motivated to "to make those claimed compounds and steps in searching for new products" using MgH<sub>2</sub> as starting materials, provided that the prior art teaches to only use a metal as a starting material, since the properties of nanostructured materials made from metals are not similar to those made from metal hydrides.

(d) As emphasized in the present application, ball milling MgH<sub>2</sub> with V creates a unique structure that cannot be obtained by ball milling Mg and V. The evidence of a ten fold increase in kinetics is a proof of that. The analysis of the hydrogen desorption kinetics of the MgH<sub>2</sub>-V nanocomposite described in the present application shows that the hydrogen desorption of this nanocomposite is interface motion controlled at 300°C under high driving force. In contrast, in the case of ball milled Mg-V nanocomposite, the hydrogen desorption at 350°C under high driving force still shows a sigmoid curve (Figures 4 & 5) and long incubation period, indicating that the nucleation of metal phase during hydrogen desorption is the rate-limiting step. The difference in hydrogen desorption mechanism indicates that the interface between the magnesium hydride and V made according to the present method and that made by using the prior art method are different although they may have the same grain or crystallite size.

(e) In the present case, it is believed that by using magnesium hydride as a starting material in the milling process helps to achieve unique particle size and distribution of the second element or compound, such as V. It is believed that this creates a unique activated interface between the hydride and the second element or compound, such as between MgH<sub>2</sub> and V. Therefore, the hydrogen dissociation and chemisorption become fast. Furthermore,

the nucleation of new phases during phase transformation also becomes fast due to the activated interface. Therefore, they are not the rate - limiting steps anymore, and consequently the kinetics become extremely fast.

(f) The reasoning for modifying the prior art references provided in the office action is a clear example of the impermissible "obvious to try" standard. As stated in MPEP 2145(X)(B):

The admonition that 'obvious to try' is not the standard under § 103 has been directed mainly at two kinds of error. In some cases, what would have been 'obvious to try' would have been to vary all parameters or try each of numerous possible choices until one possibly arrived at a successful result, where the prior art gave either no indication of which parameters were critical or no direction as to which of many possible choices is likely to be successful.... In others, what was 'obvious to try' was to explore a new technology or general approach that seemed to be a promising field of experimentation, where the prior art gave only general guidance as to the particular form of the claimed invention or how to achieve it." *In re O'Farrell*, 853 F.2d 894, 903, 7 USPQ2d 1673, 1681 (Fed. Cir. 1988) (citations omitted).

In the present case, the asserted motivation in the office action that "one of ordinary skill in the art would clearly be motivated to make those claimed compounds and steps in searching for new products" is a clear example of the impermissible obvious to try standard. Searching for new products without direction as to which of many possible choices is likely to be successful is not a proper motivation to modify the prior art references, as noted in the MPEP.

#### **D. Summary**

In summary, the Applicants believe that the claimed method is patentably different from the applied prior art for the following reasons.

(1) The claimed starting materials are different from those used in the applied prior art, which leads to unexpected properties in the resulting materials. It was not obvious for a

person of ordinary skill in the art to foresee better performance by starting from MgH<sub>2</sub> rather than from Mg.

(2) The performance of the nanocomposites made by the claimed method is about an order of magnitude better than those made by the method of the applied references. This is not foreseen from theoretical models or empirical rules based on the prior art technology. This is an unexpected result.

(3) The mechanism of hydrogen adsorption in materials made by the claimed method is believed to be different compared to the prior art materials when used under the same conditions, thereby indicating that the structures of the composite made by the claimed method are different from that of prior art, although they are both called nanocomposites.

## **II. The Double Patenting Rejections Should Be Withdrawn**

Claims 1-13 and 15-17 have been rejected under the doctrine of obviousness type double patenting over claims 1-21 of US '965. This rejection is respectfully traversed for the same reason as the 103(a) rejections above.

Independent claim 1 of the present application recites that the starting material is a metal which is subject to hydrogenation which results in a metal hydride. The metal hydride is then ground into the nanocrystalline metal hydride powder.

In contrast, US '965 discloses and claims that the starting material is a metal which is ground into a nanocrystalline powder. Thus, the claims of US '965 do not teach or suggest grinding a metal hydride into nanocrystalline powder. Therefore, the claims of the present application are not obvious over claims 1-21 of US '965.

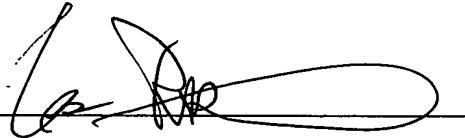
## **III. Conclusion**

Applicants believe that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested. The Examiner is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.

The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 19-0741. Should no proper payment be enclosed herewith, as by a check being in the wrong amount, unsigned, post-dated, otherwise improper or informal or even entirely missing, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 19-0741. If any extensions of time are needed for timely acceptance of papers submitted herewith, Applicant hereby petitions for such extension under 37 C.F.R. §1.136 and authorizes payment of any such extensions fees to Deposit Account No. 19-0741.

Respectfully submitted,

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